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NORTHROP GRUMMAN

Pre-Design Work Plan for Groundwater Hotspot

Operable Unit 3, Former Grumman Setting Ponds, Bethpage, New York.

May 1, 2014

ARCADIS

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Project Manager

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Operable Unit 3, Former Grumman Settling Ponds, Bethpage, New York

May 1, 2014

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Figures

Appendices

1. Introduction

This Pre-Design Work Plan for the Groundwater Hotspot (Work Plan) was prepared at the request of Northrop Grumman Systems Corporation (Northrop Grumman) to conduct a groundwater investigation to support the Operable Unit 3 (OU3) volatile organic compound (VOC) hotspot (hotspot) remedial design. Specifically, this Work Plan describes the technical objectives and approach for the pre-design groundwater hotspot investigation.

2. Background

As described in the Study Area Remedial Investigation (RI) Report (ARCADIS 2011a) and Study Area Feasibility Study (FS; ARCADIS 2011b), groundwater south of the Bethpage Community Park (Park) is impacted by volatile organic compounds (VOCs) in excess of New York State Department of Environmental Conservation (NYSDEC) Standards, Criteria, and Guidance Values (SCGs). The Park is bordered by Cherry Avenue Extension/Aerospace Boulevard and the Arumdaun Presbyterian Church Vision Center Building to the north, Stewart Avenue and Bethpage High School to the east, the former Grumman Plant 24 Access Road (Access Road) to the south and residential areas south of the Access Road, and the McKay Field Access Road and the former Grumman Plant 24 to the west. The Park location and approximate area of the hotspot (see below) are shown on **Figure 1**. Regional groundwater flow in the area is to the south/southeast, with a downward component, and is locally modified by pumping of public supply and remediation wells.

The Study Area FS recommended remedy consists of the installation of a remedial well (RW-21) to address VOC-impacted groundwater in the hotspot south of the Park. Following issuance of the FS, the OU3 Record of Decision (ROD; NYSDEC 2013) specified that the groundwater remedy would consist of one or more groundwater extraction well(s) to capture and treat 90 percent, at a minimum, of the mass discharge of VOCs in groundwater migrating from the hotspot. The hotspot is described in the OU3 ROD as an area of elevated VOCs located upgradient of the Bethpage Water District Plant 4 well field.

3. Work Plan Objectives

This Work Plan has been prepared to meet the following technical objectives:

- Further characterize the hotspot at and near the proposed location of Remedial Well RW-21 (as shown in the Study Area FS);
- Estimate the mass flux and mass discharge of VOCs migrating from the hotspot (see Section 4.3 of this Work Plan for definitions of VOC mass flux and mass discharge); and
- Confirm that the recommended remedy presented in the Study Area FS will capture and treat, at a minimum, 90 percent of the mass discharge of VOCs migrating from the hotspot or, alternatively, whether modification of the recommended remedy (e.g., additional remedial well[s]) is required to achieve that performance goal.

4. Scope of Work

4.1 Adaptive, Dynamic Work Strategies

This Work Plan is intended to be adaptive, incorporating dynamic work strategies consistent with ITRC Triad guidance (ITRC, 2007). Therefore, modifications to the approach described below may be necessary to achieve the stated objectives in the most efficient manner; as such modifications and supporting rationale for any changes in scope will be provided to NYSDEC as needed during the implementation of the work and in the final report (Section 5.0).

4.2 Hotspot Characterization

An investigation will be conducted along three proposed transects (**Figure 2**) to further characterize the distribution of VOCs in groundwater in the hotspot. The following activities are proposed:

- Evaluate the highest VOC concentrations, presumed to be in the central portion of the hotspot, by drilling a vertical profile boring (VPB) at the center of each of three transects for the purpose of collecting discrete-interval lithologic and groundwater quality samples (total of three VPBs). The data from these three VPBs will be evaluated and up to three additional VPBs may be drilled to further characterize the central portion of the hotspot (i.e., maximum of two VPBs per transect).

- Additional VPBs will be drilled along the two transects most representative of the highest VOC concentrations (i.e., maximum of five VPBs per completed transect). The results will support the estimation of mass flux and mass discharge of VOCs migrating from the hotspot (see Section 4.3). The nominal groundwater sampling interval at each VPB will be 20 feet, commencing at 300 feet below land surface (ft bls), to terminal depth (see below).

- A minimum of one VPB within the central portion of each of the three transects described above will penetrate the full thickness of the Magothy aquifer and into the very upper portion of the Raritan confining unit (minimum of three VPBs). Identification of the top of the Raritan confining unit will follow procedures detailed in the NYSDEC approved Raritan Clay identification protocol in **Appendix A**. Based on the analytical results of water quality samples and lithologic data collected from the initial three VPBs performed in the central portion of the transects, additional VPBs may be terminated at shallower depths, provided the technical objectives listed above are met.

- Following VPB drilling and geophysical logging, monitoring wells will then be installed for long-term monitoring of VOC concentrations and determination of VOC mass discharge. The lithologic data, VOC analytical results, and geophysical logs will be used collectively to identify the vertical interval(s) where the highest mass discharge of VOCs is occurring. Monitoring wells will then be installed and screened in this vertical interval(s). A minimum of three monitoring wells per completed transect are planned (a total of nine wells). The current understanding of the data suggests:

    1. Monitoring wells will be installed at depths corresponding to the middle to lower portions of the Magothy;

    2. A single vertical interval at each anticipated monitoring well location will be representative of the highest VOC mass discharge through the aquifer and correspondingly, one monitoring well is anticipated to be installed per location (i.e., well clusters are not anticipated);

    3. Three wells per transect will be sufficient to laterally bracket the area where the majority of the VOC mass discharge is occurring.

  Additional monitoring wells will be installed, as appropriate, if:

1. The data from the VPB and geophysics indicate that the majority of the VOC mass discharge is determined to occur laterally over a wider area than anticipated and/or

2. The majority of VOC mass discharge is determined to occur over a greater vertical interval or over more than one discrete interval.

- VPB and monitoring well groundwater samples will be analyzed for the Target Compound List VOCs, Freon 12, Freon 22, and Freon 113 using protocols approved by NYSDEC. Additionally, 20 Tentatively Identified Compounds (TICs) will be searched for by the laboratory. The monitoring well(s) will be surveyed by a New York State-licensed surveyor.

- Field sampling, analysis protocols and data validation for this Work Plan will be conducted according to the protocols described in the NYSDEC approved OU3 RI/FS Work Plan (ARCADIS, 2006; Appendix A for the Sampling and Analysis Plan (SAP), Appendix D for Quality Assurance Project Plan (QAPP).

4.3 Mass Flux/Mass Discharge Evaluation

VOC mass discharge will be estimated using the data from the investigation described in Section 4.2, which is based on the Interstate Technology and Regulatory Council's (ITRC) guidance document "Use and Measurement of Mass Flux and Mass Discharge" (ITRC, 2010). Consistent with the ITRC document, mass discharge is the total mass of VOCs moving in groundwater through a cross sectional plane of the aquifer perpendicular to the direction of groundwater flow. Mass flux is the rate of VOC mass movement through a unit subsection of aquifer along the cross sectional plane. Mass discharge and flux are a function of both VOC concentration and the Darcy velocity. The hydraulic data (gradients and conductivity) and VOC concentration data will be evaluated collectively and used to support the estimates of mass flux and mass discharge of VOCs from the hotspot.

4.4 Groundwater Modeling

Groundwater flow and fate and transport modeling will be used, in conjunction with the VOC mass discharge estimates, to confirm that proposed Remedial Well RW-21, as recommended in the Study Area FS, is capable of meeting the ROD-required 90 percent reduction in VOC mass discharge. If needed, the modeling and mass discharge estimates will be used to optimize the location of Well RW-21 or determine whether modification of the recommended remedy (e.g., additional remedial well[s]) is required to achieve the ROD performance goal.

4.5 Borehole Abandonment

Borings not used for monitoring well installation purposes will be abandoned, following the appropriate closure protocols included in NYSDEC's DER-10 and Groundwater Monitoring Well Decommissioning Policy (NYSDEC 2009).

4.6 Investigation-Derived Waste

Investigation derived waste produced during sampling activities will be collected, containerized, and temporarily stored at the Northrop Grumman facility before being characterized (as required by the disposal facility) and disposed off-site at a Northrop Grumman-approved facility.

4.7 Decontamination

A decontamination pad will be constructed on Northrop Grumman property for decontamination of large equipment, such drill rigs and tools. Decontamination fluids will be collected and stored in drums, pending characterization and disposed off-site at a Northrop Grumman-approved facility.

4.8 Health and Safety

The health and safety procedures, detailed in the Site-Specific Health and Safety Plan (ARCADIS 2013), will be followed for work carried out according to this work plan. Air monitoring for volatile organic compounds (VOCs) and particulates (i.e. dust) will be performed at designated work areas in accordance with the Community Air Monitoring Plan included in the NYSDEC-approved RI/FS Work Plan (ARCADIS, 2006; Appendix A, Attachment A-1).

A project contact list is provided in **Appendix B** of this Work Plan.

5. Reporting

A Pre-Design Report will be prepared following completion of the work described herein to present the data, mass flux/mass discharge evaluation of VOCs, and groundwater modeling results. Collectively the information will be used to confirm whether the recommended remedy presented in the Study Area FS will capture at least 90 percent of the mass discharge of VOCs from the hotspot or whether modification of the recommended remedy (e.g., re-locate RW-21, additional remedial well[s]) is required to achieve the ROD performance goal. If re-location of RW-21 is proposed, the revised location will be provided. Likewise, if one or more additional remedial wells are proposed, the number and locations of the wells will be provided.

6. Estimated Schedule

See **Figure 3** for the Pre-Design Work Plan for Groundwater Hotspot portion of the OU3 Combined Pre-Design Work Plan Schedule.

7. References

ARCADIS of New York, Inc. (ARCADIS) 2006. Remedial Investigation/Feasibility Study Work Plan. Operable Unit 3 – Former Grumman Settling Ponds, Bethpage, New York. NYSDEC Site #1-30-003A. March 2006.

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ARCADIS 2013. Site Specific Health and Safety Plan, Northrop Grumman Systems Corporation, April 2013.

Environmental Management & Global Innovations, Inc. (EMAGIN) 2014a. Pre-Design Sampling Work Plan for VOC Source Area Operable Unit 3, Former Grumman Settling Ponds, Bethpage, New York. January 2014

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ITRC (Interstate Technology & Regulatory Council), 2010. *Use and measurement of mass flux and mass discharge*. MASSFLUX-1. Washington, D.C.: Interstate Technology & Regulatory Council, Integrated DNAPL Site Strategy Team.

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New York State Department of Environmental Conservation. 2013. Record of Decision, Former Grumman Settling Ponds (Operable Unit 3 – Bethpage Community Park), Bethpage, New York. NYSDEC Site # 1-30-003A. March 2013.

New York State Department of Environmental Conservation (NYSDEC). 2009. DER-10, Technical Guidance for Site Investigation and Remediation, New York State Department of Environmental Conservation, November 3, 2009.

New York State Department of Environmental Conservation (NYSDEC). 2009. CP-43 Groundwater Monitoring Well Decommissioning Policy, New York State Department of Environmental Conservation, November 3, 2009.

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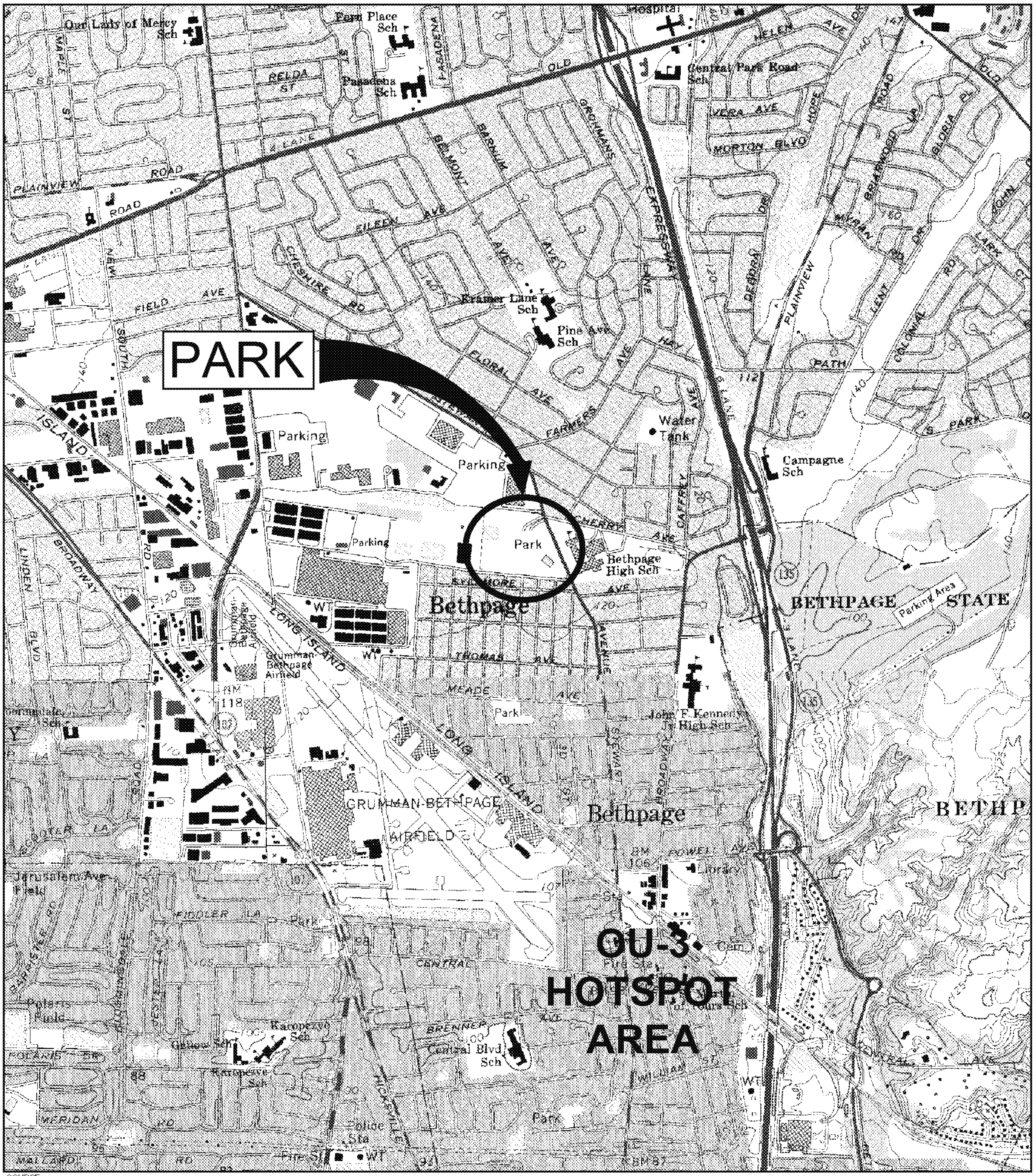
Figures



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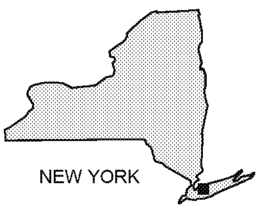
USGS 7.5 MIN AMITYVILLE QUADRANGLE, AMITYVILLE, N.Y., 1994, FREEPORT QUADRANGLE, FREEPORT, N.Y., 1994,
HICKSVILLE QUADRANGLE, HICKSVILLE, N.Y., 1967, PHOTOREVISED 1979, HUNTINGTON, N.Y., 1967, PHOTOREVISED 1979



0 2000' 4000'

SCALE IN FEET

NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3
(FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

PARK AND HOTSPOT LOCATION

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FIGURE
1

CITY:SYRACUSE-NY DIV/GROUP:ENV DB:A.SANCHEZ LD: PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\NY001496\Site Location Map.dwg LAYOUT: OU3HOTSPOT SAVED: 11/5/2013 9:11 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 11/5/2013 2:01 PM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: AMITYVILLE.TIF FREEPORT.TIF HICKSVILLE.TIF HUNTINGTON.TIF PROJECTNAME: ----

LEGEND:

PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE

LONG ISLAND RAILROAD

RECHARGE BASIN

TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)

STUDY AREA PUBLIC SUPPLY WELL

EXISTING MAIN FACILITYREMEDIAL WELL (TOWER 102)

EXISTING SYSTEM INFLUENT PIPELINE

PROPOSED REMEDIAL WELL

PROPOSED SYSTEM INFLUENT PIPELINE

PROPOSED TRANSECT

BWD BETHPAGE WATER DISTRICT

TVOC TOTAL VOLATILE ORGANIC COMPOUND

OU3 VERTICAL PROFILE BORING USED TO DEPICT VOC-IMPACTED GROUNDWATER DOWNGRADIENT OF THE PARK AND ALSO AIDED IN SELECTING THE CURRENTLY PROPOSED TRANSECTS

0 900' 1800'

APPROXIMATE SCALE IN FEET

NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

SITE PLAN SHOWING TRANSECTS

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FIGURE
2

FIGURE 3: OU3 COMBINED PRE-DESIGN WORKPLAN SCHEDULE

ID	Task Name	Duration (Cal. Days)
1	OU3 Consent Order Executed	0 days
2	**Residential Property Delineation/Pre-Design**	**338 days**
3	**Project Planning and Coordination**	**76 days**
4	DEC/DOH obtain access agreements from property owners	2 mons
5	Bidding and contracting	2 mons
6	NG Notice to Proceed to Consultant	0 days
7	**Field Work**	**162 days**
8	**Phase 1A Soil Investigation**	**55 days**
9	Utility clearance, contractor mobilization	2 wks
10	Soil sampling	1 mon
11	Laboratory analysis & data validation	1 mon
12	**Phase 1B Soil Investigation**	**38 days**
13	Soil sampling	2 wks
14	Laboratory analysis & data validation	1 mon
15	**Phase 2 Soil Investigation**	**69 days**
16	Phase 2 Soil Investigation letter work plan submittal	0 days
17	DEC/DOH work plan approval	3 wks
18	Soil sampling	1 mon
19	Laboratory analysis & data validation	1 mon
20	Residential Pre-Design Report preparation/submittal	3 mons
21	**OU3 Hot Spot Sampling**	**456 days**
22	**Project Planning and Coordination**	**97 days**
23	Bidding and contracting	2 mons
24	NG Notice to Proceed to Consultant	0 days
25	Locate potential drill sites, permits, access, public notification	3 wks
26	Utility clearance, contractor mobilization	2 wks
27	**Field Work**	**287 days**
28	Install VPBs and monitoring wells	39 wks
29	Monitoring well sampling	1 wk
30	**Laborary Analysis, Data Validation, Modeling & Reporting**	**345 days**
31	Laboratory analysis; data validation	43 wks
32	Groundwater modeling	3 wks
33	OU3 Hot Spot Sampling Report preparation/submittal	3 mons
34	**Bethpage Park VOC/PCB Sampling**	**311 days**
35	**Project Planning and Coordination**	**69 days**
36	Access agreement and permitting with TOB	1 mon
37	Bidding and contracting	2 mons
38	NG Notice to Proceed to Consultant	0 days
39	**Field Work**	**121 days**
40	Contractor mobilization, site clearing, utility clearance, sampling grid survey, and measure ball field cover and adjust planned sampling depths	4 wks
41	Soil sampling/PCB screening	3 mons
42	Soil sampling/VOC screening	2 mons
43	**Laboratory Analysis and Data Validation**	**107 days**
44	PCB/metals laboratory analysis	3 mons
45	PCB/metals data validation	3 mons
46	VOC laboratory analysis	2 mons
47	VOC data validation	2 mons
48	**Reporting**	**93 days**
49	PCB sampling report preparation/submittal	3 mons
50	VOC sampling report preparation/submittal	3 mons
51	**Bethpage Park GW Hydraulic Effectiveness Evaluation**	**243 days**
52	**Project Planning and Coordination**	**103 days**
53	Bidding and contracting	2 mons
54	NG Notice to Proceed to Consultant	0 days
55	Permits, access	2 wks
56	Utility clearance, contractor mobilization	2 wks
57	**Field Work**	**93 days**
58	Install VPBs and monitoring wells	9 wks
59	Install piezometers and additional monitoring wells	6 wks
60	Monitoring well/piezometer sampling	2 wks
61	**Laboratory Analysis, Data Validation, and Reporting**	**133 days**
62	Laboratory analysis/data validation	15 wks
63	Park GW Effectiveness Report preparation/submittal	7 wks

Schedule assumes no delays in task implementation caused by:
- Obtaining site access agreements
- Obtaining drilling and other required permits
- DEC/DOH work plan reviews/approvals
- Lack of availability of drillers or mobile laboratories
- Weather and other force majeure events
- Additional delineation and sampling required beyond locations and depths identified in work plans
- Actions or involvement of regulatory/governmental agencies other than NYSDEC and NYSDOH
- Other project-related conditions or events beyond the control of Northrop Grumman

The schedule will be revised as needed to account for delays caused by any of the above conditions.

Project: OU3 Combined Work Plan Schedule
Date: 5/1/14

Legend: Task; Split; Milestone; Summary; Project Summary; External Tasks; External Milestone; Manual Task; Manual Summary Rollup; Finish-only; Deadline; Progress

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Appendix A

Raritan Identification Protocol

Raritan Confining Unit Field Identification Protocol

(November 16, 2012 MODIFED version)

Introduction

This is a modification of the standardized protocol developed in February 2012 (ARCADIS 2012) for field identification of the Raritan Confining Unit (RCU) (i.e., the hydrogeologic designation for the unnamed clay member(s) of the Upper Cretaceous-age Raritan Formation on Long Island, New York). This protocol is intended as guidance for field geologists/scientists during oversight of drilling for selecting split-spoon sampling and Hydropunch groundwater sampling intervals and the depth to terminate vertical profile borings drilled along the Northrop Grumman Site southern boundary, and incorporates data from VPBs completed since issuance of the February 2012 RCU protocol, specifically Northrop Grumman VPBs VP3-1, and VP-73R/VP-33 drilled and sampled along the Northrop Grumman western and southern boundaries, respectively, and Navy VPBs VP-134, VP-135, and VP-136, drilled and sampled along the southern boundary of the former Naval Weapons Industrial Reserve Plant (NWIRP). This modified protocol was specifically developed to take into account the data developed by the Navy from the above mentioned three VPBs. These recent VPBs drilled by the Navy revealed three distinct clay layers at approximately 600, 700, and 800 feet below land surface (bls) as well as intervening sand units underlying the 600 and 700 ft clays. This modified protocol will allow the same three clays to be documented in VP-74 if they exist at this location and soil and groundwater samples to be taken from the intervening sand units. However, the Navy data indicate no site-related VOC detections below the 600 ft clay. If similar results are obtained from VP-74 then any future VPBs that may be drilled by Northrop Grumman will use the original (February 2012) and not this modified protocol. While this protocol was specifically prepared for field staff overseeing the drilling and sampling of deep boreholes that are part of the On-site Containment (ONCT) System Hydraulic Effectiveness Evaluation program performed for Northrop Grumman Systems Corporation, in Bethpage, New York (Northrop Grumman), this protocol will be useful to other investigators in confidently identifying this unit. As described in the February 2012 protocol, this update is intended to be a flexible field guide that can be adjusted to fit site-specific field conditions based on the geologists/scientists experience. This protocol stresses the need to adequately identify: 1) the RCU and in so doing confirm that the transmissive Magothy aquifer and any substantial sandy layers in the Raritan Formation, through which advective transport of impacted groundwater could occur, has been fully penetrated and 2) in the case of the ONCT system evaluation program, the vertical extent of volatile organic compound (VOC) contamination in groundwater. The RCU is generally hard, solid clay of substantial thickness that severely restricts the exchange of groundwater (and by extension impacted groundwater) between the Magothy aquifer and the deeper Lloyd aquifer. Across Long Island, the large head differences measured between these two aquifers (at well clusters that screen both aquifers) is testament to the significant character of the RCU as a local and regional confining unit. For the purpose of this ONCT investigation, the RCU can be considered the bottom of the aquifer system.

Raritan Confining Unit and Magothy Aquifer Lithology and Depositional Environments

The RCU and overlying Magothy aquifer are the "hydrogeologic equivalents" of the Raritan Formation clay member and Matawan Group – Magothy Formation, undifferentiated, respectively. They are both Upper Cretaceous age units whose depositional origin is considered to be continental in nature (generally thought to be an environment of streams and coalescing deltas). The deposits in each unit include gravel, sand, silt, and clay. The differentiation between the units is not easily made based on mineral or sand type identification methods (both units generally contain quartzose sands with pyrite, iron oxide concretions and lignite common) but rather is more readily made from a hydrogeologic perspective based on grain size relative to the percent occurrence of that grain size within the unit. That is, a clay lense sample from the Magothy aquifer may look extremely similar to a clay sample from the Raritan clay, however, from an overall percent occurrence of clay encountered within the two units, clay is significantly more abundant in the RCU (with extensive lateral continuity). Color of deposits may also be used to assist in unit identification (gray clay and pink/red clay from Magothy and Raritan, respectively) however; it is by no means definitive. A more common and reasonably reliable field method of differentiation is to observe the transition of deposits encountered in the vertical sequence. Although the Magothy is characterized primarily by fine to medium sand, silt, and clay lenses, typically the basal zone exhibits a marked increase in grain size to the extent that the basal Magothy horizon is identified by its coarse sand, gravel, to even cobble size deposits. These coarse deposits typically rest directly on the erosional or non-depositional unconformity that separates the two units. The unconformity marks a vast change in the depositional environment, from very high energy (coarse deposits) to much lower energy levels (clay). The transition from the basal gravel zone is typically abrupt and the clay of the Raritan is encountered directly beneath the gravel zone however, the basal gravel zone has been noted to not always be present. Encountering this sequence of deposits, used in conjunction with all other available information and interpretations has commonly been used to mark this hydrologic unit boundary across Long Island.

Procedures for Implementing the Protocol

The following are procedures for identification and characterization of the RCU and a framework for field staff to make decisions. As described in the preceding section, the mineralogy, grain size, color, etc. of the Magothy aquifer and RCU are not easily distinguishable when comparing single samples from each unit. More importantly for the purposes of these investigations, the existence, thickness, and continuity of clays encountered is most important rather than the ability to differentiate the deposits based on age or geologic name. The focus should be on identifying the transition through the coarse basal Magothy horizon into the fine clay deposits of the Raritan. Most certainly, geophysical logs of such deep borings are invaluable in also identifying a sharp transition zone and correlating lateral features.

1. Review applicable literature

a. Review Smolensky and others (1989)-"Hydrologic Framework of Long Island, New York" and specifically Sheet 2 of 3- the map showing the "Altitude of the Upper Surface of the Raritan Confining Unit" to obtain an initial indication of the expected altitude of the top of the RCU at a planned drilling location(s) by locating the proposed borehole(s) to be drilled on this map. For convenience in the field during drilling oversight, use a topographic map of the area or a nearby surveyed elevation to convert the expected RCU altitude to a depth in feet below land surface.

b. Review Buxton and others (1989)-"Hydrogeologic Correlations for Selected Wells on Long Island, New York-A data base with retrieval program" which is the companion publication to the Smolensky report referenced above and contains the basic data on which that report was based. Look in the Buxton report for wells near the planned drilling location(s) to obtain more site specific information to refine the expected depth to the RCU.

c. Review data from Vertical Profile Borings VP-73R and VP-33, which were completed in January and March 2012, respectively as part of the Phase 1 ONCT System Hydraulic Effectiveness Evaluation program, and which reached and penetrated into the RCU. The borings were advanced approximately 28 and 22 ft below the top of the unit, and the RCU deposits were characterized as light gray to red solid clay. Immediately overlying the clay was a horizon of sub-round to round quartz pebbles. Gamma logs confirmed the abrupt change in deposit type. Also review data from VP-3-1 which also penetrated the RCU but at a greater depth (over 80 feet) than the RCU was reached at VP-73R and VP-33. At VP-3-1, the clay was dark gray and the horizon of pebbles was not present immediately above the RCU.

d. Review data from other recently completed borings that have penetrated the RCU in the general area. Of particular interest are recent Navy VPBs VP-134 (westernmost VPB), VP-135, and VP-136 (easternmost VPB), completed in mid-2012. These VPBs were completed north of the ONCT Hydraulic Effectiveness Evaluation area and penetrated a sequence of three clay units separated by sandy sequences. The first clay was encountered between 635 and 636 ft bls and ranges between 11 and 22 ft in thickness. This clay thins to the east ("600 ft clay") and does not appear to be present at VP-136 although a 5-ft thick clay was found at a depth of 565 feet and another clay 5-ft thick was found at a depth of 678 feet. The second, more substantial clay was encountered between 699 and 720 ft bls and ranges between 46 and 57 ft in thickness, ("700 ft clay"). The third clay was only fully penetrated in VPB VP-135, and the depth to the clay ranges between 813 and 820 ft bls and its thickness ranges from 37 ft in VP-135 to greater than 59 ft in VP-136 ("800 ft clay"). Generally, these clays are characterized as competent, dry and dark gray in color. Based on the depths and thicknesses of the clays, it is expected that these units will be encountered at somewhat deeper depths along the Northrop Grumman southern boundary. Sandy sequences were noted at the VPBs as follows:

VPB ID	Thickness of Sand Sequence below "600 ft clay"	Thickness of Sand Sequence below "700 ft clay"
VP-134	54 ft	62 ft
VP-135	53 ft	58 ft
VP-136	37 ft *	47 ft

* *Assuming 683 ft is concluded to represent the bottom of the "600 ft" clay sequence at VP-136.*

Based on data provided by Navy, VOCs were not detected at depths greater than 598 ft bls, 478 ft bls, and 581 ft bls in VP-134, VP-135, and VP-136, respectively.

2. Drilling and split-spoon sampling

a. Communicate the objective of the borehole to the driller before commencing drilling and maintain communication throughout the borehole drilling to obtain his observations on material being penetrated by the drill bit. Ask him to tell you when he is drilling in sand or gravel and when he believes the borehole is penetrating clay or silt. Periodically note the drilling fluid pressure (if using a fluid based drilling technique and the rig has such a gage) as pressure increases may indicate penetration of a low permeability layer such as silt or clay.

b. While drilling through the Magothy aquifer, examine and describe split-spoon samples (according to ARCADIS' Standard Operating Procedure for Soils) for evidence of the RCU based on the descriptions given above for these units. If drilling is carried out using drilling fluid, note any color changes in the fluid that might indicate that the RCU has been reached. Generally, the Magothy tends to be gray with some white, but the RCU tends to be red, brownish-red, and pink. The red to brownish-red RCU frequently contains very thin white layers, which collectively can produce a pinkish color in the drilling fluid once the RCU has been penetrated.

c. Be aware that the basal zone of the Magothy aquifer is typified by coarse sand and gravel, and small cobbles have even been encountered in this horizon. The basal Magothy coarse zone may be tens of feet thick and at some locations may be up to 75 to 100 feet thick however, it is not always present. This horizon is reflective of a high energy environment and many times will stand in stark contrast to the fine sediment of the low energy environment of the underlying RCU.

d. Once the borehole reaches a depth close (30 feet above) to the anticipated depth of the surface of the "600 ft clay" based on the literature and borings described above, increase the split-spoon sampling frequency to every 5 feet. Along the Northrop Grumman site southern boundary, it is anticipated that the RCU will be encountered between 630 and 650 ft bls, so 5 ft interval split spoon samples should commence at 600 ft bls. After the first spoon sample suggestive of the RCU (see above section "**Raritan Confining Unit and Magothy Aquifer Lithology and Depositional Environments"** for RCU descriptions) is observed, continue split-spoon sampling at 5 ft intervals through the "600 ft" and "700 ft" clays as wells as intervening sand sequences, until the "800 ft clay" is encountered. Split spoon sampling will then continue at 5 foot intervals with the goal of penetrating a minimum of 20 feet of the "800 ft" clay. If the material penetrated in the "800 ft" clay is predominantly clay characteristic of the RCU, the boring will be terminated. In addition, at any time during drilling through the clay should the driller convey that sand has been encountered, drilling will be suspended and a decision will be made with the office staff as to whether an additional split spoon(s) will be collected. **It is very important to note any significant changes in grain size (particularly zones of potentially higher transmissivity) at the base of the Magothy aquifer and in the intervening sands between the clay sequences noted above.**

e. If during split-spoon sampling it is no longer possible to advance the split spoon (i.e., refusal is reached-decided in the field with driller input) when the borehole has penetrated into the "800 ft" clay, then the driller will be instructed to complete steps 2f through 3b. If the geophysical logging indicates that the basal 20 ft of the borehole is predominately clay then the borehole can be terminated. However, if the geophysical logging indicates that the interval is not predominately clay then a decision should be made, with office project management staff, to either attempt to conduct additional drilling/split-spoon sampling or terminate the borehole. If the borehole has only reached the "600 ft" or "700 ft" clay then drilling should continue and split spoon sampling should be attempted again after drilling an additional 10 ft.

f. Once the drilling has been terminated, if using a fluid based drilling system, request the driller to slowly re-drill the borehole portions opposite each clay member encountered that is characteristic of the RCU to ensure that any swelling of the clay into the borehole is overcome and the borehole remains open to its full drilled diameter. Also, ask the driller to continue to circulate the drilling fluid until all entrained sediment has reached the fluid pit and settled out to the extent practical to help ensure that the borehole remains open to its full drilled depth so that geophysical logging can be effectively carried out.

3. Geophysical logging

a. Have the driller pull the rods from the borehole and then proceed with geophysical logging of the borehole (gamma ray log). However, if there are concerns about borehole stability the gamma ray log may be run inside the rods.

b. Review the split-spoon geologic descriptions and compare to the gamma ray log to confirm that the RCU has been reached and is predominately clay and, if confirmed, then drilling can be considered terminated.

4. **VOC groundwater sampling**

a. The modified Hydropunch sampler should be used to collect groundwater samples for VOC and field parameters (pH, specific conductance, temperature) analysis. Hydropunch samples will not be attempted from the clay units described above. Hydropunch samples will be collected following each split spoon from the basal Magothy zone at 5 ft intervals, beginning 30 ft above the expected top of the RCU (see **2d** above) and at 10 ft intervals from intervening sandy zones between the three major clay members described above. Should split spoon samples from intervening sandy zones between the clay members listed above indicate a zone of substantially higher transmissivity (e.g., coarse sands or gravels), then an additional Hydropunch sample will be collected from that interval.

Water samples collected as part of this protocol will be analyzed for VOCs by a fixed location laboratory on a 24-hour turnaround basis.

ARCADIS

Appendix B

Project Contact List

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Project Contact List
Operable Unit 3 (OU3) Pre-Design Work Plans

The NYSDEC and NYSDOH have established toll-free numbers that citizens can call to ask questions or discuss the project. The toll free numbers are as follows:

NYSDEC: 1-800-388-8223
NYSDOH: 1-800-458-1158, ext. 27880

The following project-related individuals may also be contacted for information about the project:

New York State Department of Environmental Conservation
Steven Scharf
Project Manager
625 Broadway
Albany, NY 12233-7015
(518) 402-9620

New York State Department of Health
Steve Karpinski
Public Health Specialist
Empire State Plaza
Corning Tower, Room 1787
Albany, NY 12237
(518) 402-7860

Nassau County Department of Health
Joseph De Franco
200 County Seat Drive
Mineola, NY 11501
(516) 227-9697

Northrop Grumman Systems Corporation-Aerospace Systems
Timothy Paynter
Director of Communications
2980 Fairview Park Drive
Falls Church, VA 22042
(703) 280-4359